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PERFORMANCE STUDY OF A SOLAR STILL WITH SALT HYDRATE AS ENERGY STORAGE MEDIUM

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ABSTRACT

A Solar still is a low cost device used for purifying water. Its low productivity is of great concern. Its low productivity is due to poor performance of solar still during off sunshine hours. Many passive solar still have been designed and developed to improve the daily distillate output from the solar still. Energy storage medium is used to enhance the productivity during off sunshine hours. In the present work salt hydrate Mg $(NO_3)_2.6H_2O$ *is used as energy storage material in a single basin single slope solar still. Experimental studies are performed in the premises of SHUATS Allahabad, U.P. India and it is observed that the use of Mg* $(NO_3)_2.6H_2O$ *as energy storage medium in the solar still increases the daily productivity by 22%.*

Key words: Solar still, Salt hydrate, Phase Change Material

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1. INTRODUCTION

Drinking water is essential for life. Water covers three fourths of the earth surface, but 97% of that is salty. Access to pure drinking water is becoming difficult day by day in the developing countries. Due to rapid growth of population, heavy industrialization, and increasing pollution has worsen the situation. Desalination may be a proper solution but it requires a lot of energy. Solar energy is renewable and sustainable in nature. Solar thermal desalination system gives the better solution to solve drinking water shortage problem. Solar still is a very simple and easy to construct and low cost device. It has many features but the daily productivity from the solar still is insufficient to make it commercial. Different solar still designs (Rai et al. (2013), Khare et al.(2015), Pandey et al. (2016)) have been tested to improve productivity. Limited sunshine hours and poor performance during off

sunshine hours are the two basic reasons behind low daily productivity of solar stills. Energy storage mediums can be used to improve nocturnal output. Abhat (1983), Rai et al (2012), have reviewed work on PCMs and their wide range of applications. Shukla et al (2011), Rai et al (2013), Rai et al. (2015), Hasan et al.(2014), Kumar et al. (2014) and Kumar et al. (2016) used PCM as a energy storage medium in the solar still to improve the daily productivity of solar still. It was reported that the productivity of a solar still can be greatly enhanced by the use of a PCM integrated to the still. In the present study, an attempt has been made to test the performance of a single slope solar still with salt hydrate Mg $(NO_3)_2.6H_2O$ as energy storage material in the basin of the still. The most attractive properties of salt hydrates are: (i) high latent heat of fusion per unit volume (ii) relatively high thermal conductivity (almost double of the paraffin's) and (iii) Small volume changes on melting. They are not very corrosive, compatible with plastics and only slightly toxic. Many salt hydrates are sufficiently inexpensive for the use in storage.

2. EXPERIMENTAL SET-UP AND PROCEDURE

Figure 1 shows the photograph of two similar single slope solar stills. They are kept on the same platform during experimentation. PCM is loaded in the basin of one of the still while the other still is kept conventional. Passive solar distillation unit consist of water basin of area $1m^2$. The basin of the still is made up of Galvanized iron. Mass of 4.9 kg of PCM is filled in the thin Aluminums pipes, which are spread in the basin. Basin is now filled with water. Glazing glass cover of thickness 3mm is used as condensing cover. Inclination of the glass covers are at 30^0. A distillate channel was provided at each end of the basin for the collection of distilled water. The distillate was collected in thin necked containers and then measured by graduated beaker. Stills were insulated properly by using glass wool.

Figure 1 Experimental Set up of Single Slope Solar Still With and without PCM

The experiments were conducted in the premises of SHUATS Allahabad U.P.India in the month of October and November. Experiments started at 8:30 AM at local time. Measuring instruments were caliberated properly. The distillate output was recorded with the help of a measuring cylinder of least count 1 ml. The solar intensity was measured with the help of caliberated solarimeter of least count 2 mW/m^2. Anemometer is used to measure the wind velocity.

3. PRODUCTIVITY AND EFFICIENCY OF THE SOLAR STILL

The daily yield M_w can be obtained by adding hourly yield. Energy analysis of a solar still is based on the principle of conservation of energy. Expression for the solar still daily efficiency can be obtained as follows.

$$\eta_{energy} = (M_w \times L) / (A_s \times \Sigma^{I}_{t(s)} \times 3600) \quad (1)$$

L is the latent heat of vaporization and is obtained by the expression

$$L = 2.49\ 35 \times 10^6 \times [1-9.4779 \times 10^{-4} T_w + 1.3132 \times 10^{-7} \times T_w^2 - 4.7974 \times 10^{-9} \times T_w^3] \quad (2)$$

T_w is basin water temperature in ^0C. $\Sigma^{I}_{t(s)}$ is the daily solar intensity. As is the basin area of the still in m^2.

4. RESULTS AND DISCUSSION

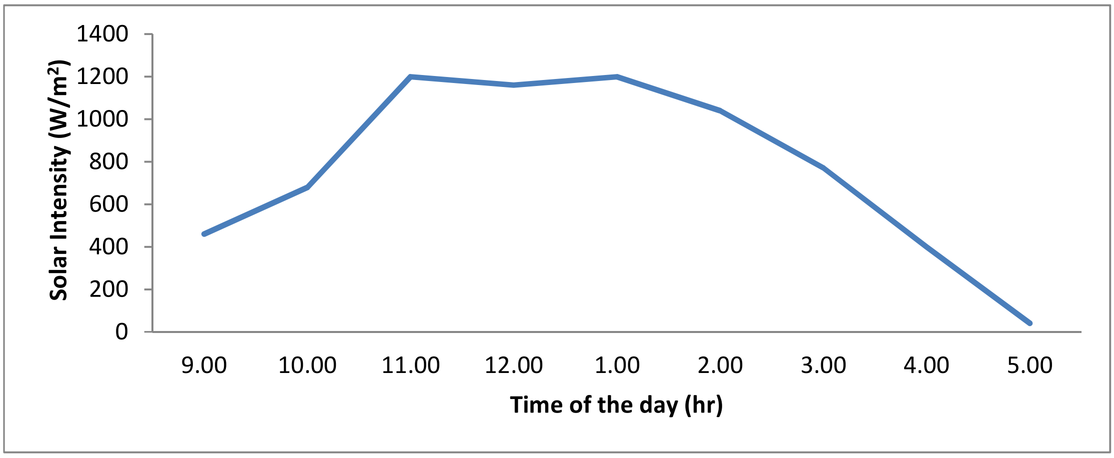

Figure 1 Variation of solar intensity with time of the day

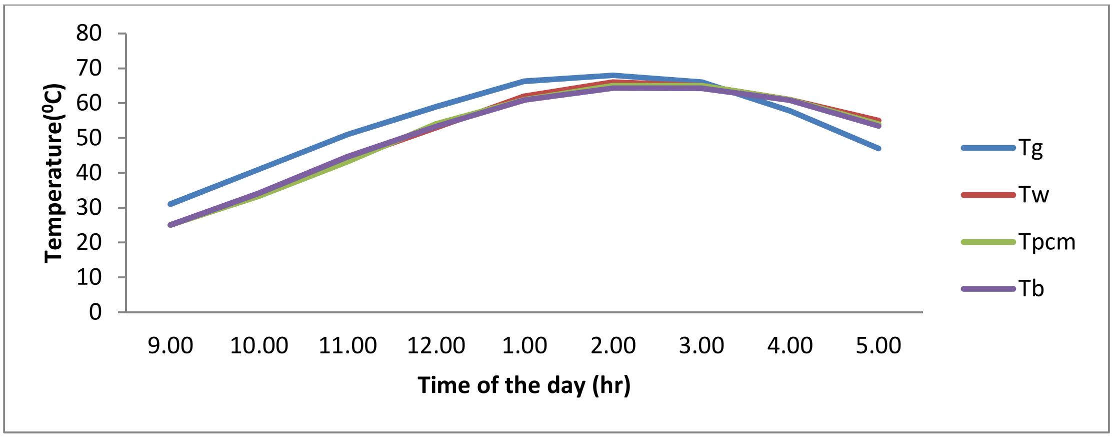

Figure 2 Variation of Temperature of different components of the solar still with PCM

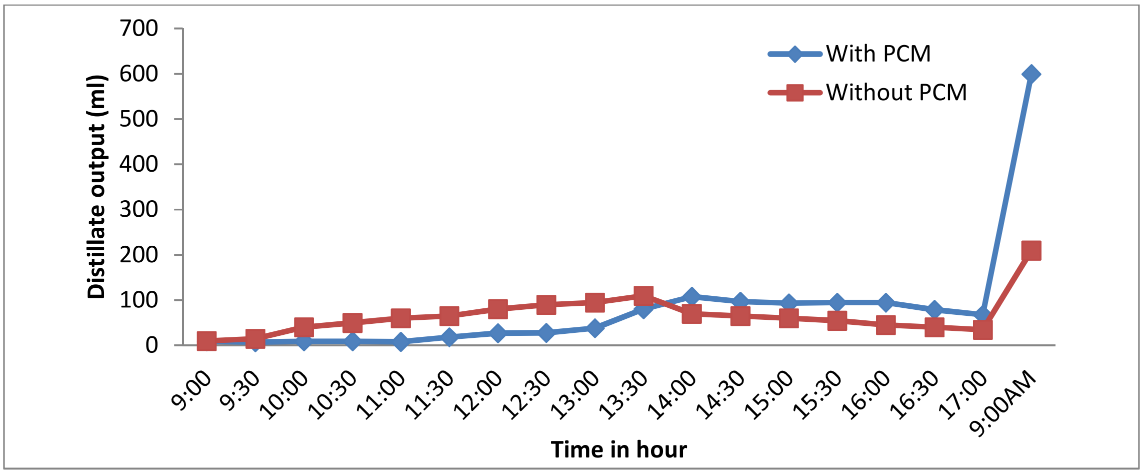

Figure 3 Variation of distillate output with respect to time of the day

Figure 1 shows the variation of solar intensity with respect to the time of the day for a particular day in the month of October of Indian climatic conditions. As expected, solar intensity is maximum since 11 to 1 PM with slight lower due to presence of cloud. It increases in the fore noon and shows the tendency to decrease in the same manner in the afternoon. South facing glass cover receives more intensity. Fig. 2 shows the variation of temperature of the different components of the solar still with respect to time of the day.Temperature of basin, water and energy storage medium is observed very close but a significant temperature difference is observed between the water and the glass cover. Temperature of the glass cover is higher in fore noon, but due to green house effect temperature of water, PCM and water basin reaches maximum in afternoon. Due to decrease in solar intensity, glass cover cools faster in afternoon.Sides and basin are insulated to conserve heat.Temperature of PCM is lower than water temperature during charging mode. Discharging of PCM, heats the water in the basin and the base temperature is maintained higher than the water temperature. Fig. 4 shows that distillate output in afternoon is more in the PCM assisted still than the conventional still. Use of PCM in the basin of the still increases the daily productivity by 22.9%. Day time distillate produced by the PCM assisted still is less by 11.8% than the conventional still because out of total heat received by the basin, part of it goes to charging the PCM. It is clear from fig 4. that in the fore noon conventional still gives better productivity than the PCM assisted still. Night time distillate output from the PCM assisted still is 185% more than the conventional still. PCM assisted still is found more efficient than the conventional still.

5. CONCLUSIONS

In the present study an attempt has been made to test the performance of solar still assisted with salt hydrate $Mg(NO_3)_2.6H_2O$ as thermal energy storage material in the solar still, which absorbs heat energy during sunshine hours and releases the same during off sunshine hours with little or negligible variation in its temperature. An experimental work was carried out on two similar, single basin single slope passive solar stills. The PCM is used in the basin of one of the still to find its suitability in terms of the performance of the still. It is observed that the use of PCM in the basin of the still increases the daily productivity by 22.9%. Day time distillate output decreases by 11.8% but night time distillate output increases by 185%.

REFERENCES

[1] A. Abhat, 1983 Low temperature latent heat thermal energy storage: heat storage materials, Solar Energy 30 313-332.

[2] El-Sebaii A. A., Al-Ghamdi A.A., Al-Hazmi F.S. and Faidah A.S. 2009, Thermal performance of a single basin solar still with PCM as a storage medium, Applied Energy, 86, 1187-1195.

[3] Hasan Falih M., Dr. Ajeet Kumar Rai, Vivek Sachan, Omar Mohammed (2014). Experimental Study of Double Slope Solar Still with Energy Storage Medium, International Journal of Advanced Research in Engineering and Technology: 5(3) 147-154

[4] Khudhur Ihshan mohammed and Rai Ajeet Kumar (2014), Experimental Study of a tubular solar still integrated with a fan. International Journal of Advanced Research in Engineering and Technology: 5 (3) 01-08.

[5] Kumar Maheep, Rai Ajeet Kumar and Sachan Vivek (2014), Experimental Investigation of a Solar Still Using Lauric Acid as a Energy Storage Medium, International Journal of Advanced Research in Engineering and Technology, 5(12) 35-40.

[6] Khare Neha, Rai Ajeet Kumar and Sachan Vivek (2015), Experimental Study on a Stepped Basin Solar Still, International Journal of Advanced Research in Engineering and Technology, 6(7) 24-29.

[7] Kumar Maheep , Rai Ajeet Kumar (2016), Performance study of a phase change material assisted solar still. International Journal of Advanced Research in Engineering and Technology,7(1) 60-67.

[8] Murugavel KK, Chockalingam Kn K S K Srithar K, 2008 Progresses in improving the effectiveness of the single basin passive solar still Desalination 220; 677–686

[9] Pandey Narayan and Rai Ajeet Kumar (2016), Performance study of solar still with separate condenser, International Journal of Mechanical Engineering and Technology, 7(4) 125-130. ISSN Print: 0976-6340, ISSN Online: 0976-6359.

[10] Rai Ajeet Kumar and Kumar Ashish 2012, A review on phase change materials and their applications. International journal of Advanced Research in Engineering and Technology (IJARET) 3(2), pp 214-225.

[11] Rai Ajeet Kumar, Sachan Vivek and Kumar Maheep (2013), Experimental Investigation of a double slope solar still with a latent heat storage medium, International Journal of Mechanical Engineering and Technology: 4 (1) 22-29.

[12] Rai Ajeet Kumar, Singh Nirish and Sachan Vivek (2013), Experimental study of a single basin solar still with water cooling of the glass cover. International Journal of Mechanical Engineering and Technology: 4 (6) 1-7.

[13] Rai Ajeet Kumar, Sachan Vivek and Nandan Bhawani., (2013) Experimental study of evaporation in a tubular solar still, International Journal of Mechanical Engineering and Technology: 4 (2) 1-9.

[14] Rai Ajeet Kumar, Singh Pratap, Sachan Vivek and Bhaskar Nripendra. (2013), Design, Fabrication and Testing of a modified single slope solar still. International Journal of Mechanical Engineering and Technology: 4 (4) 8-14.

[15] Rai Ajeet Kumari, Sachan Vivek , Tripathi Vinay , Kumar Pramod and Tripathi Abhishek (2014), Effect of lowering condensing surface temperature on the performance of solar still, International Journal of Mechanical Engineering and Technology, 5(8) 41-48. ISSN Print: 0976-6340, ISSN Online: 0976-6359

[16] Rai Ajeet Kumar , Sachan Vivek , (2015), Experimental study of a Tubular Solar Still with Phase Change Material. International Journal of Mechanical Engineering and Technology, 6(1) 42-46. ISSN Print: 0976-6340, ISSN Online: 0976-6359

[17] Singh Ankur Kumar, Rai Ajeet Kumar and Sachan Vivek (2014) Energy and Exergy Analysis of a Double Slope Solar Still International Journal of Mechanical Engineering and Technology :5(6) 47-54

[18] Shukla S.K. and Ali A. Farhan, (2011) Thermal Modelling of Solar Stills Using PCM as Storage Medium, accepted for oral presentation at ASME-ES Fuel Cell 2011 conference to be held at Washington D.C. USA during August 7-10.

[19] Shukla S.K. and Rai A.K., (2008) Analytical Thermal Modelling of Double Slope Solar Still by Using Inner Glass Cover temperature, Thermal Science, Vol.12(3),139-152.

[20] Shukla S.K. and Rai A.K., (2010) Estimation of Solar Still output Under Indoor Environment, International Journal of Applied Engineering Research:, Vol. 5(2), 343-350.

[21] Sadhana, Rai Ajeet Kumar , Sachan Vivek , and Kumar Maheep (2015), Experimental study on a Finned Basin Solar Still, International Journal of Mechanical Engineering and Technology, 6(7) 16-20.

[22] Tiwari Devashish and Rai Ajeet Kumar (2016), Effect of sensible energy storage medium on the productivity o solar still, International Journal of Mechanical Engineering and Technology, 7(4) 1-7.